Notes on the Ecology and Development of Plagiogyria fialhoi

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Plagiogyria fialhoi (Fée & Glaziou) Copel. is a shade-loving fern that can be found in cloud forests of elevated regions in the Brazilian states of Rio de Janeiro, Espirito Santo, Minas Gerais, São Paulo, Santa Catarina, Rio Grande do Sul, and probably also Paraná (Brade, 1956; Sehnem, 1967). Some authors (e.g., Tryon & Tryon, 1982) consider *Plagiogyria* in America to be a single species, *P. semicordata* (Presl) Christ, but in this study the separation into six species by Lellinger (1971) was adopted.

Some aspects of the ecology and development of the gametophytes and sporophytes of a population of *P. fialhoi* occurring in a cloud forest in the Serra da Mantiqueira in southeastern Brazil (45°25′S, 22°40′W, ca. 2,000 m alt.) were studied. The locality is on a small ridge next to the Campos do Jordão State Park, in the state of São Paulo. Cloud forests occur mainly on the eastern slopes of the mountains, above 1,600 and up to 2,000 m alt., and are composed of low (ca. 6 m) trees covered by a great quantity of epiphytes. Frequent drizzle, fog, and low clouds keep the humidity extremely high. The rainfall at the locality is thought to be about 2,000 mm per year.

Climatological data collected at considerably lower altitudes in the nearby state park (Seibert et al., 1975) indicate July as the driest month (ca. 30 mm rainfall) and January as the wettest (more than 300 mm). The warmest month is February (17.7°C average, absolute maximum 27.2°C); the coldest is July (9.5°C average, absolute minimum −4.4°C). A short description of the floristic composition of these cloud forests is presented by Seibert et al. (1975), together with the detailed climatic data for the region.

MATERIALS AND METHODS

Gametophytes and ca. 60 young sporophytes with fronds up to 3 cm long were collected and preserved in weak chromo-acetic fixative (Sass, 1951); 36 larger specimens were pressed (voucher specimens at HRCB). Frond longevity was studied in 15 plants by marking their youngest fronds and following their development during visits 240 and 374 days later (February and June, 1982). The complete underground parts (rhizome, roots, and stipe bases) of ten well developed specimens were carefully removed and the shape and position of the rhizome correlated with the topography.

The average number of fronds per adult plant was calculated from data from the ten removed specimens (April, 1981) and from the 15 marked plants (June, 1981). Average size of the fronds was obtained based on those of the 10 removed specimens and confirmed later (March, 1983) by measuring 128 adult fronds. The distance between the elements of 55 pairs (nearest neighbors) of plants was measured.

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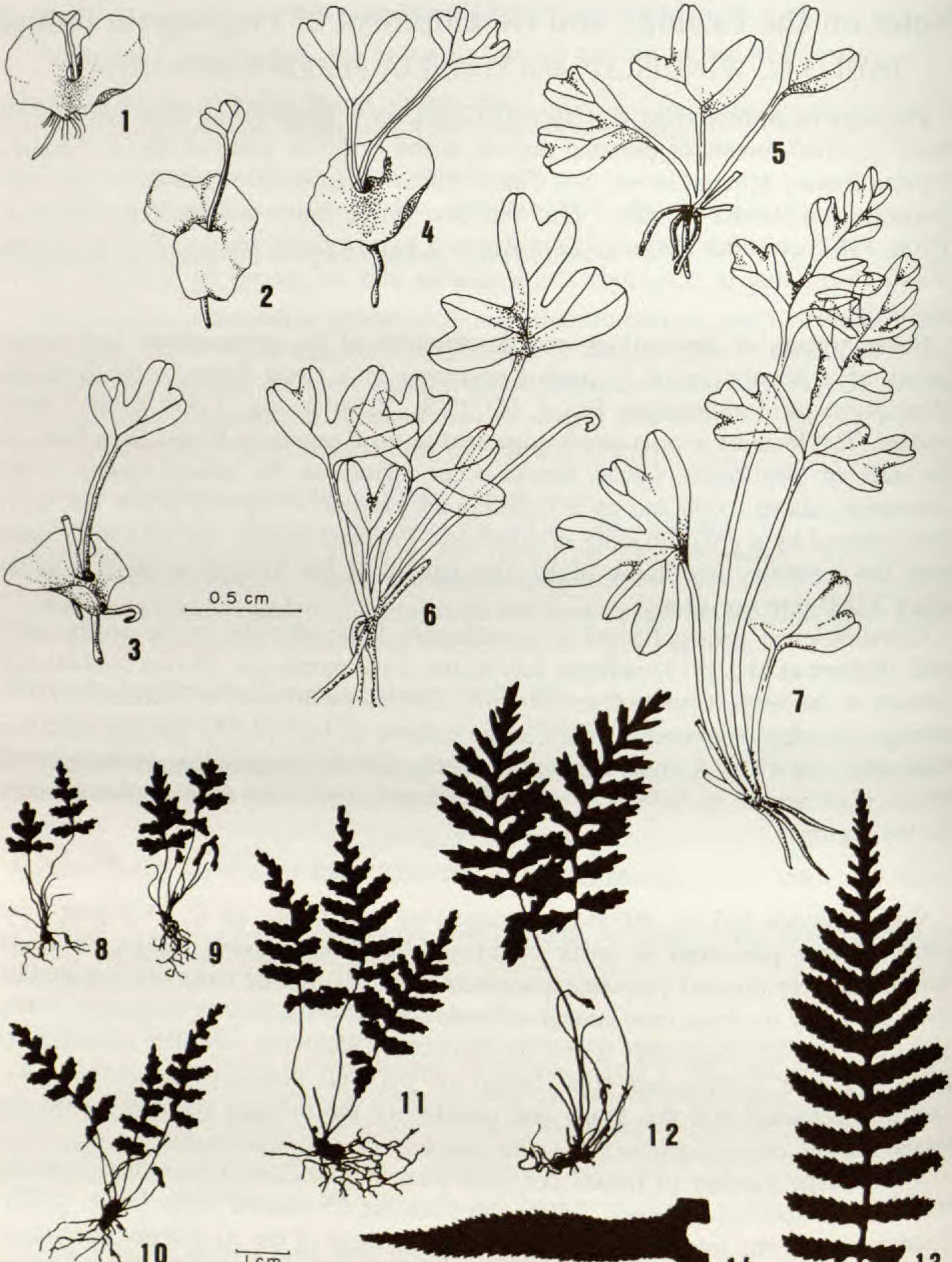


FIGS. 1–14. Gametophytes and heteroblastic development of the sporophyte of *Plagiogyria fialhoi*. FIGS. 1–4. Gametophytes attached to young sporophytes. FIGS. 5–12. Sporophytes in diverse stages of development. FIG. 13. Lamina of a frond 15.5 cm long. FIG. 14. Pinna from the middle of a frond 40 cm long.

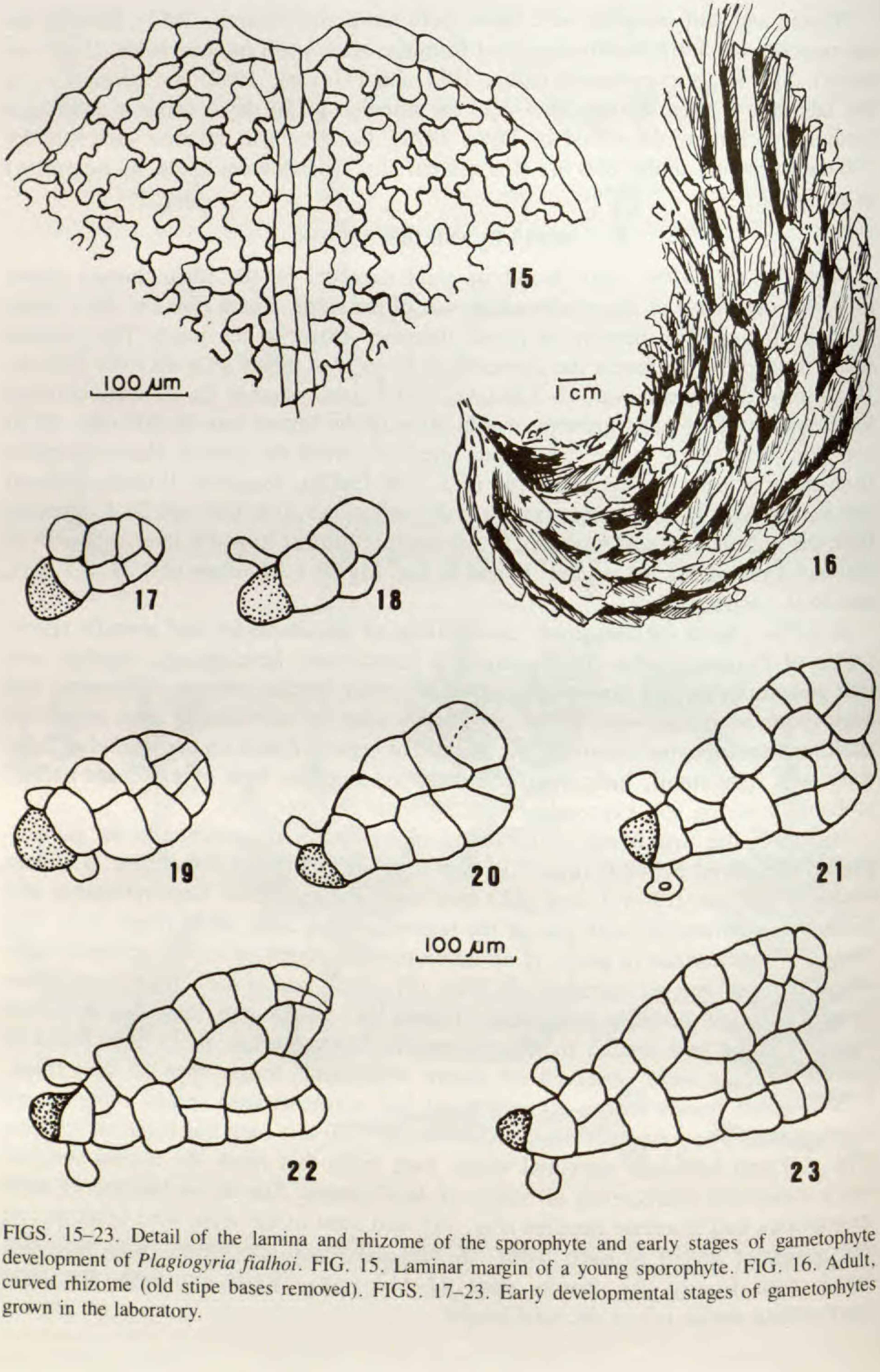
Humus and soil samples were taken from ten points (March, 1983), keeping the top material (0–5 cm depth) separated from the humus-soil mixture below (5–10 cm depth). Spores were collected (June, 1981 and February, 1982) and germinated in the laboratory after storage at 3–5°C for three and 120 days, using a solid agar medium (technique described by Dyer, 1979). Gametophyte cultures were kept for 100 days growing under 850 lux (fluorescent plus incandescent bulbs, 12 hours/day) at ca. 24°C.

RESULTS AND DISCUSSION

Plants of *P. fialhoi* were found in great numbers on the steep, humid slopes (30–50% declivity) of the southeastern side of the ridge, which rises ca. 70 m above a small stream. The density of plants increases closer to the water. The distance (nearest neighbor) between the elements of 21 pairs of plants growing more than ca. 10 m from the stream was 45–520 (ave. 189.4) cm, whereas the distance between the elements of 34 pairs growing within 10 m of the stream was 18–300 (ave. 95.9) cm. The plants grew in the rich humus layer that covers the ground. Humus samples from the top layer (5 cm) had a pH of 3.2 (in $CaCl_2$); 48μg/cm^3 P (resin method) and K, Ca, Mg, H + Al values (m. eq. 100 cm^3) of 0.5, 0.8, 0.6, and 24.4. Samples from the humus and soil mixture (19.6% organic matter) from the layer below (5-10 cm) had a pH of 3.1; 43 μg/cm^3 P; and K, Ca, Mg, H + Al values of 0.29, 0.2, 0.3, and 46.0, respectively.

In a few places on the slope, associations of gametophytes and juvenile sporophytes of *Plagiogyria* in diverse stages of heteroblastic development, together with fern gametophytes and young sporophytes of other species, mosses, liverworts, and angiosperm seedlings were found. In contrast with the surrounding area, where the adult fern sporophytes occurred, the amount of organic matter on the ground at those spots was very small, indicating that these associations were of a pioneer nature, probably covering soil exposed by running water or fallen trees.

In nature, the first frond of the young sporophytes (still attached to the gametophytes) measured 5.5–8.0 (ave. 7.0) mm long, with stipes 3.0–5.2 (ave. 3.9) mm long and laminae 1.3–4.3 (ave. 3.1) mm long. These laminae were symmetric and bilobed or asymmetric with one of the segments once more lobed (*Figs. 1–5*). The margin of the laminae in plants of all developmental stages presented a characteristic row of more or less rectangular cells (*Fig. 15*), which was of basic importance in the identification of juvenile specimens. Fronds ca. 14–35 mm long had a central vascular strand and tended to form pinnatifid laminae (*Figs. 6–7*). Pinnatisect to pinnate laminae were observed on plants with fronds longer than 35 mm (*Figs. 8–13*). These fronds (up to 80 mm long) had segments with serrate margins and simple veins. The lower pinnae of fronds ca. 85–150 mm long had biserrate margins (*Fig. 13*) and bifurcate proximal veins. Free veins that reach the lamina margins was a consistent character in all stages of development. The sterile laminae of adult sporophytes had biserrate margins (*Fig. 14*), and most of the veins were bifurcate, so that a veinlet ended in each tooth. In well developed specimens (with rhizomes longer than 6 cm) the fronds were 43–117 (ave. 75.68) cm long, the stipe representing about 1/3 of the total length.



FIGS. 15–23. Detail of the lamina and rhizome of the sporophyte and early stages of gametophyte development of *Plagiogyria fialhoi*. FIG. 15. Laminar margin of a young sporophyte. FIG. 16. Adult, curved rhizome (old stipe bases removed). FIGS. 17–23. Early developmental stages of gametophytes grown in the laboratory.

Fertile fronds were observed from February to June. It seems that they are formed around January and probably persist until July. Viable spores were collected in June, 1981. A visit in February, 1982 revealed many young fronds, but the spores collected from the most developed of these did not germinate. These data indicate a definite periodicity of fertility. Fertile fronds measured 70–117.5 (ave. 103.0) cm long (the stipe representing about 1/2 of the total length) and were usually longer than the sterile fronds of a given plant. The minimum ratio observed for numbers of sterile to fertile fronds observed was 10:4, the maximum 21:1.

The rhizome, covered with the bases of fallen fronds and adventitious roots, was usually erect if no longer than 4 cm, but curved in larger specimens so that the vegetative parts usually were level with or barely above the litter on the ground. The older parts remained buried. The apex of each rhizome bore the fronds in a rosette protecting frond primordia and young fronds. Litter carried down the slope accumulated against the frond-covered rhizome apices. The resulting pressure on the uphill side and perhaps a more intense washing of the ground on the other side, together with apical rhizome growth, promoted a slow and gradual movement of the whole plant downhill. The rhizome and its semi-decayed remains are curved, with the main axis oriented down the slope. In a large specimen, the angle of deviation between the alignment of the rhizome apex and that of the oldest remains was ca. 155° (*Fig. 16*), indicating the change of relative position of the old parts in the ground due to the downhill movement.

The one year-long observation of marked fronds revealed that fronds persisted for about one year. The number of fronds on adult plants (of different ages) was 9–21 (ave. 12). Therefore, the minimum age of a plant can be estimated by dividing the total number of stipe bases by 12. On very old specimens, the semi-decayed parts still present are of large size, indicating that at the time those were formed the plant was already well developed. One specimen with a rhizome 21 cm long had a minimum age of 24 years. The youngest fertile specimen collected had a rhizome 12 cm long; its age was estimated to be more than 15 years, indicating a minimum spore-to-spore life cycle of considerable duration. Vegetative reproduction was not observed, although Bower (1926) cited the occurrence of stolons in *P. pycnophylla* (Kunze) Mett. and bifurcation of the rhizome in *P. semicordata*.

Spores sown on culture media three days after collection did not germinate up to 30 days after sowing, but after 50 days, germinating spores and gametophytes with 3, 4, 9 and 12 cells were seen. Slow germination occurring at irregular intervals was also observed in cultures of *P. glauca* (Blume) Mett. and *P. semicordata* by Stokey and Atkinson (1956). This kind of gradative germination can explain the finding in nature of gametophytes together with young sporophytes in diverse stages of development in a single small area. Spores stored for 120 days showed an extremely low germination rate; a single spore in about 2,000 germinated after 30 days, reconfirming the short viability of the spores of this genus as discussed by Stokey and Atkinson (1956) and Nayar and Kazmi (1962).

The first stages of gametophyte development (*Figs. 17–20*) are very similar to those described by Nayar and Kazmi (1962) for *P. triquetra* Mett. No apical meristematic cell was observed. The development of a heart-shaped apex (*Figs.*

21–23) started earlier (65 days after sowing) than in the Old World species studied by Nayar and Kazmi (1962). Elongated young plate stages and filamentous stages as cited for *P. glauca* and *P. semicordata* by Stokey and Atkinson (1956) were not observed; perhaps they were a consequence of the physical conditions under which Stokey and Atkinson's material was grown. They considered the probability of competition with algae as being the cause of these elongated plate stages, but our cultures were also heavily contaminated. Unfortunately, the algae were so numerous that further development of the gametophytes could not be followed in the laboratory. In nature, we found that mature gametophytes were cordiform (up to 4.4 mm wide, 5.3 mm long at the larger wing), generally with one of the wings overlapping the other (*Figs. 1–4*), and had a thick central region.

This study was made possible by the cooperation of the officers of the Forestry Institute of the State of São Paulo, Campos do Jordão State Park and by support from the Conselho Nacional de Desenvolvimento Científico e Tecnológico—CNPq (Proc. 30.1339/77 and Proc. 10.6254/79), the Universidade Estadual Paulista Júlio de Mesquita Filho—UNESP, and the Fundação de Amparo à Pesquisa do Estado de São Paulo—FAPESP (Proc. 81/1369-5).

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